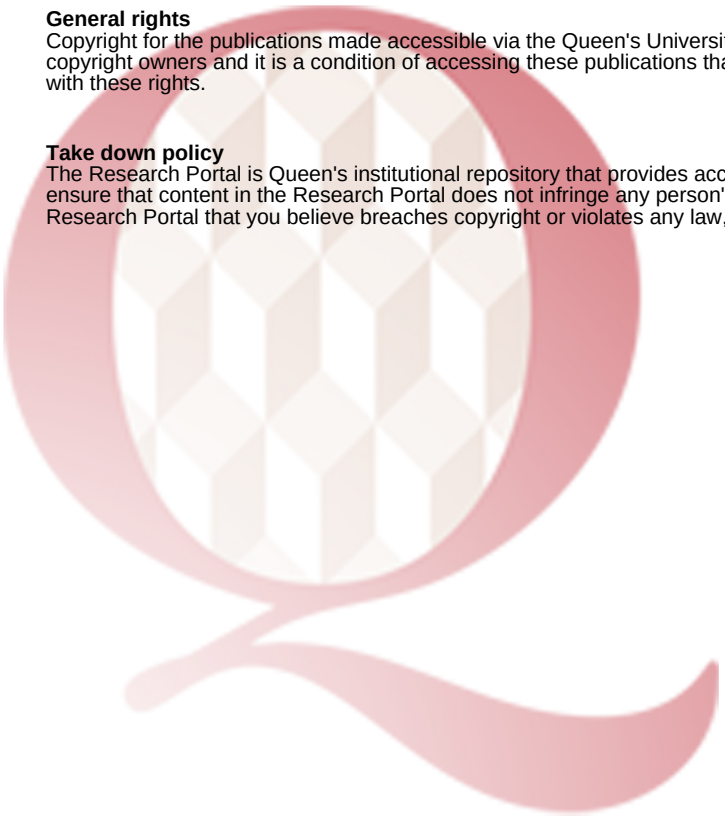
Advances in single-shot, dry drilling of composite/metal stacks



Advances in single-shot, dry drilling of composite/metal stacks

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Carbon fibre reinforced polymers (CFRP) are increasingly being used in the aerospace, automotive and defence industry due to their high specific stiffness and good corrosion resistance. In a modern aircraft, 50-60% of its structure is made up of CFRP material while the remainder is mostly a combination of metallic alloys (typically aluminium or titanium alloys). Mechanical fastening (bolting or riveting) of CFRP and metallic components has thus created a pressing requirement of drilling several thousand holes per aircraft. Drilling of stacks in a single-shot not only saves time, but also ensures proper alignment when fasteners are inserted, achieving tighter geometric tolerances. However, this requirement poses formidable manufacturing challenges due to the fundamental differences in the material properties of CFRP and metals e.g. a drill bit entering into the stack encounters brittle and abrasive CFRP material as well as the plastic behaviour of the metallic alloy, making the drilling process highly non-linear.

Over the past few years substantial efforts have been made in this direction and majority of the research has tried to establish links between how the process parameters (feed, depth of cut, cutting speed), tooling (geometry, material and coating) and the wear of the cutting tool affect the hole quality. Similarly, multitudes of investigations have been conducted to determine the effects of non-traditional drilling methods (orbital, helical and vibration assisted drilling), cutting zone temperatures and efficiency of chip extraction on the hole quality and rate of tool wear during single shot drilling of CFRP/alloy stacks.

In a timely effort, this paper aims at reviewing the manufacturing challenges and barriers faced when drilling CFRP/alloy stacks and to summarise various factors influencing the drilling process while detailing the advances made in this fertile research area of single-shot drilling of stack materials. A survey of the key challenges associated with avoiding workpiece damage and the effect these challenges have on tool design and process optimisation is presented. An in depth critique of suitable hole making methods and their aptness for commercialisation follows. The paper concludes by summarising the future work required to achieve repeatable, high quality single shot drilled holes in CFRP/alloy stacks.